

HABITAT USE AT NIGHT BY WINTERING AMERICAN WOODCOCK IN COASTAL GEORGIA AND VIRGINIA

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ABSTRACT.—Nocturnal habitats used by American woodcock (*Scolopax minor*) were studied using radio telemetry at two coastal wintering sites in Georgia (1982–84) and Virginia (1991–92). In Georgia, use of forested habitats at night was extensive while use of fields at night varied between years but generally was low. We found no difference in the probability of moving to a field at night among the four age-sex classes ($P = 0.23$). A significant effect ($P < 0.05$) of age-sex class was noted between distances moved from diurnal to nocturnal locations in Georgia. Young females moved farther than any other age-sex class. In Virginia, no effect of age-sex class was found on the probability of being located during the night in either a field or a forest. Received 30 June 1994, accepted 15 May 1995.

Wintering American woodcock (*Scolopax minor*) frequent both forests and fields at night (Roberts 1993). During the night on the wintering grounds, woodcock conduct two main activities, feeding and roosting (Roberts 1993). At night on the winter grounds, unlike on the summer grounds, woodcock feed so extensively (Glasgow 1958, Dyer 1976, Stribling and Doerr 1985) that most food requirements probably are met at this time (Dyer 1976, Roberts 1993). In addition to feeding, roosting occurs at night (Glasgow 1958, Dyer 1976, Britt 1971, Connors and Doerr 1982). Roosting in fields may reduce predation (Connors and Doerr 1982). As evidence of their vulnerability to predation at night, woodcock have developed supposed anti-predator behaviors while roosting, e.g., non-random positioning in roosting fields (Connors and Doerr 1982). The need for such behaviors can be understood since survival rates on the wintering grounds generally are low compared to other times of the year (Krementz et al. 1994). In an average winter along the Atlantic coast, about 20% of arriving woodcock are depredated before spring migration (Krementz et al. 1994). While some work has been done on roosting behavior and characterizing openings used at night by wintering woodcock (Roberts 1993), only a single study has followed individual woodcock to determine the frequency of use and variety of habitats used at night. Horton and Causey (1979) monitored radio-marked woodcock in the Piedmont of Alabama and found that slightly more observations occurred in forested areas (56%) than in openings (44%), and that a variety

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of habitat types (≥ 5) were used. An age-sex class effect on use of openings versus forests at night was found with adult males and immature females using openings and forests equally, young males using openings more than forests, and adult females using forests more than openings (Horton and Causey 1979).

Because woodcock populations in eastern North America have declined since the 1970s (Kendall and Bruggink 1994), and because our understanding of the variety of habitats used at night as well as the frequency of use of those habitats is not well known (Horton and Causey 1979, Roberts 1993), we initiated a study, in part, to document the variety of habitats used at night and to investigate the effects of age and sex on habitat use at night. We also report here previously collected data designed to address these same concerns (G. Haas and J.T.S., U.S. Fish Wildl. Serv., unpubl. data).

STUDY AREAS AND METHODS

We used two study sites: coastal Georgia and Virginia. The first study area was along the southern shore of the Altamaha River near Everett, Georgia. The predominant land use was timber managed primarily for pine pulpwood. Pine plantations were clear-cut followed by intensive post-cutting management including windrowing, seed-bed preparation, fertilization, planting with loblolly pine (*Pinus taeda*) or slash pine (*P. elliotii*), and sometimes herbiciding. Society of American Foresters (SAF) (Anonymous 1975) forest cover types represented at this site included loblolly pine, loblolly pine-hardwood, sweetgum-nuttall oak-willow oak (*Liquidambar styraciflua*, *Quercus nuttallii*, *Q. phellos*), overcup oak-water hickory (*Q. lyrata*, *Carya aquatica*), baldcypress-water tupelo, (*Taxodium distichum*, *Nyssa aquatica*), water tupelo, sweetbay-swamp tupelo-red maple (*Magnolia virginiana*, *N. sylvatica*, *Acer rubrum*). We lumped all forest types which contained a predominance of oaks in wetter sites into the SAF type group, bottomland hardwood. Four small (< 5 ha) corn fields and six pastures (5–50 ha) were located within 3 km of the center of the study site. The corn fields were disked in the fall leaving little crop residue. The pastures ranged from lightly to heavily grazed. The second study area was the Eastern Shore of Virginia National Wildlife Refuge (ESVNR) and adjacent farmlands located on the southern tip of the Delmarva Peninsula near Cape Charles, Virginia. It was characterized by agricultural fields scattered among older woodlots of mixed pine-hardwood. Little forest management was evident in the area. SAF forest types included black cherry (*Prunus serotina*), black locust (*Robinia pseudoacacia*), loblolly pine, loblolly pine-hardwood, and sweetgum-yellow poplar (*Liriodendron tulipifera*). We also included 1 non-forest habitat type, waxmyrtle (*Myrica* spp.). Agricultural crops ≤ 5 km from the refuge included soybeans, corn and winter wheat. All crops were usually disked in the fall, making them relatively flat with virtually no crop residue. No fallow croplands were available ≤ 2 km from the refuge. Two fallow soybean fields between two and three years old, and a single abandoned grass airstrip were located on the refuge. None of the six fields on the refuge nor any fields nearby (≤ 5 km) were either clearcuts, regrowth, or pine < 3 m (see below).

We classified all managed pine sites by age. Managed pine plantations were classified as (1) pine < 3 m—sites planted with pines and usually < 5 growing seasons, (2) pine 3–9 m—sites planted with pines and usually 5–15 growing seasons, and (3) pine > 9 m—sites planted with pines and usually > 15 growing seasons. We classified all pine sites which were not

managed after cutting as (1) clearcut—<1 growing season old, (2) regrowth—between one and three growing seasons old, and (3) shrubland—>3 growing seasons old. The latter two types were predominantly occupied by blackberry (*Rubus* spp.), oak (*Quercus* spp.) saplings, and broom sedge (*Andropogon virginicus*). We further classified habitat types into forested and field types. Fields included clearcuts, regrowth, shrubland, pine <3 m, cropland, and pastureland. Under the definition that a field is an area without a tree canopy that is closed, then the inclusion of pine <3 m tall as a field type is clear cut. As an indication that pine <3 m should be a field type was the observation that male woodcock regularly performed aerial courtship flights at these sites (D.G.K., unpubl. data). All other habitat types were considered forested.

Both study areas were characterized by relatively mild winter weather. The mean number of days with the daily minimum temperature $\leq 0^{\circ}\text{C}$ during December–February recorded at the weather stations closest to the study areas were: Norfolk, Virginia—45; and Waycross, Georgia—30 (1951–75 period, NOAA 1978). Soil temperatures at 10 cm depth were rarely $< 0^{\circ}\text{C}$ (NOAA 1982–92); any freezing of surface soil was of short duration.

Study sites were not monitored simultaneously. Study dates were: (1) Georgia: December 1982–February 1983, December 1983–March 1984, and (2) Virginia: December 1991–March 1992.

Woodcock were initially located at each study site by conducting crepuscular flight surveys at openings (Glasgow 1958) and by searching openings for the presence of probe holes and feces (Glasgow 1958, Boggus and Whiting 1982). Once sites with woodcock were located, we captured woodcock using ground traps (Liscinsky and Bailey 1955), mist nets (Sheldon 1971), and nightlighting (Riefenberger and Kletzly 1967). Upon capture, woodcock were banded with a U.S. Fish Wildlife Service leg band, weighed, aged and sexed (Mendall and Aldous 1943, Martin 1964). A radio transmitter was attached dorsally between the wings using either monofilament line or a single multi-strand wire loop harness and livestock tag cement (McAuley et al. 1993). Transmitters weighed 3.5–5.0 g ($\leq 3\%$ of body mass).

We radio-marked all woodcock captured each year before 31 January. Marked birds were tracked daily from vehicles with 4- or 6-element yagi antennas. Lost (censored) birds were searched for by air (Gilmer et al. 1981) within a 50 km radius of the capture sites.

In Georgia, birds were monitored four times daily, once every 6 h. Time permitting, each bird was approached on foot to <8 m. To ensure that the location was positive, the marked bird was circled (McAuley et al. 1993). Otherwise, locations of birds were estimated via triangulation. No investigation of telemetry location error was conducted. Locations were plotted to the nearest 50 \times 50 m block on a USGS 7.5 min series map during each of the four monitorings. The date, time and cover type at the location of the bird were recorded. Sometimes woodcock moved into fields at night and then returned to forested sites during the same night. In these cases, we recorded that the bird did use a field at night. We estimated the distance moved between the location of the bird during the afternoon and its location that night to the nearest 50 m. Again, if the bird moved to a field and then returned to the forest, we recorded the distance that it moved to the field.

In Virginia we monitored the exact location of the marked birds diurnally by circling the bird on foot. Nocturnally, we monitored whether marked birds were in forested or field habitats, but nocturnal locations were not taken daily. We attempted to record nocturnal locations every other day. All fields used were bordered by roads allowing us to determine if a radio-marked woodcock was in a field or not. We only monitored birds after the evening crepuscular period until 23:00 h. Some woodcock could have moved into the fields after this time and been undetected.

Between the diurnal and nocturnal location, each woodcock had three possible responses: (1) no measurable movement, (2) a measurable movement but remained in the same habitat

type, and (3) a measurable movement and moved to a different habitat type. We decided to analyze the data taking into consideration our confidence in determining the location of a woodcock at night. At the most accurate level, our analyses assumed that we could locate each bird accurately and precisely. These analyses were based on categorizing movements into no movement between the diurnal and nocturnal location (nocturnal location - diurnal location = 0 m), and any movement between diurnal and nocturnal location (nocturnal location - diurnal location > 0 m). The next level of analyses assumed that we could determine the cover type accurately. These analyses used no change in habitat type between the diurnal location and nocturnal location as no movement versus a change in habitat type between the diurnal and nocturnal location as a movement. Thus 2 levels of accuracy were pursued in these analyses.

To investigate potential effects of age and sex on movement, we modeled the number of movements between habitats (forest to field) for each bird as a binomial random variable with the movement rate parameters within each age-sex class following a beta distribution. This allowed for each bird to have its own movement rate and sample size. We used likelihood ratio tests to compare the means of the beta distributions among the age-sex classes. This tested whether average movement rates varied among the age-sex classes. We used the same procedure with data from young males, which had reasonable sample sizes in both years, to test for differences in movement rates between years.

The next analysis used a four-factor ANOVA to examine whether the average distance moved between diurnal and nocturnal locations differed between ages, between sexes, and whether or not habitat changed. Factors were ages, sexes, movement, and individual woodcock (nested within age and sex classes). Sums-of-squares appropriate for unbalanced designs (SAS 1990; type III model) were used; the mean-square for the individual was used as the error term to test for age and sex effects and Satterthwaite's adjustment was used to estimate the appropriate degrees-of-freedom (Milliken and Johnson 1984). Observations were restricted to dates where more than five individuals were monitored daily.

In Virginia, the irregular nocturnal monitoring precluded us from examining the effects of age and sex on movement probability or distance moved. However, we felt that we could investigate whether age or sex affected the probability of moving into a field or remaining in forested habitat nocturnally. We did so using a two-way ANOVA. Only woodcock monitored more than five times were used in these analyses.

RESULTS

Of the 21 woodcock captured in 1982-83, only three were adults which precluded analyzing age effects and only four were females precluding analyzing sex effects (Table 1). Sample sizes in 1983-84 were much better for adults (Table 1), and we were able to examine age-sex class effects in that year. Sixteen woodcock were removed from analyses in 1983-84 because they were observed less than five times each. Adult males were also poorly represented in the Virginia sample, and adults were less common than young (Table 1). We chose to examine age effects in Virginia. Only two young woodcock from Virginia were excluded from analyses because they were observed <5 times each.

Georgia

In Georgia no radio-marked woodcock used cropland or pastures at night in either year. In 1982-83, we spotlighted both habitat types 10

TABLE 1
 SAMPLE SIZES BY AGE, SEX, LOCATION AND YEAR OF AMERICAN WOODCOCK WINTERING IN
 COASTAL GEORGIA AND VIRGINIA^a

	Young males	Young females	Adult males	Adult females	Total
Georgia 1982–1983	10 (3)	3 (2)	2 (0)	1 (0)	16
Georgia 1983–1984	22 (4)	11 (6)	10 (4)	7 (2)	50
Virginia 1991–1992	27 (1)	34 (1)	2	7	70

^a Numbers in parentheses represent the number of birds captured, observed <6 times, and not used in analyses.

times in December and January (70 h total) and observed no woodcock. Based on experiences in 1982–83, we did not spotlight either habitat type in 1983–84.

Virtually all woodcock during both years made measurable movements between their diurnal and nocturnal locations (367 of 386 observations in 1982–83, 899 of 938 observations in 1983–84). In 1983–84, no age-sex class effects were found when we compared those age-sex classes moving versus not moving for: (1) woodcock making a movement to any habitat type ($\chi^2_3 = 2.33$, $P = 0.51$), (2) woodcock making any movement and ending up in forested habitats ($\chi^2_3 = 4.55$, $P = 0.21$), and (3) woodcock making any movement and ending up in field habitats ($\chi^2_1 = 1.80$, $P = 0.18$). No age-sex class effects were found for any of these tests because virtually all woodcock moved during the crepuscular period.

During both years, woodcock were usually located in forested habitat types during the day (Table 2). In particular, bottomland hardwoods were used extensively during the day (82%, 1982–83; 78%, 1983–84). In 1982–83, woodcock moved from bottomland hardwoods most often to pine plantations with pines <3 m tall (62%, Table 2), followed by remaining in bottomland hardwoods (32%). We did not test the effects of age-sex class on use of habitat at night in 1982–83 because of small samples, but in total, woodcock either remained in or moved to fields about 67% of the time. Most of the movement to fields was to the pine <3 m type (93%, Table 2).

In 1983–84, woodcock remained at their diurnal location 35% of the time, while they moved to a different location at night that was forested 52% of the time, and they moved to a different location at night that was an opening during the remaining 13% of the time (Table 2). When woodcock were located in forested habitat during the day, they typically remained there at night (743 of 861 observations).

TABLE 2
 NUMBERS OF OBSERVATIONS OF RADIO-MARKED AMERICAN WOODCOCK WINTERING IN
 COASTAL GEORGIA DURING 1982-1983 AND 1983-1984

	To nocturnal location					Σ	
	Pine <3 m	Pine 3-9 m	Pine >9 m	Bottom- land hardwood	Cypress- tupelo		Clearcut/ Re- growth/ shrub- land
1982-1983							
From diurnal location							
Pine <3 m	23	1	0	2	0	1	27
Pine >9 m	0	0	1	0	0	0	1
Bottomland hardwood	197	2	0	101	2	14	316
Cypress-tupelo	3	0	0	0	0	0	3
Clearcut/regrowth/shrubland	6	10	0	3	0	20	39
Σ	229	13	1	106	2	35	386
Only from bottomland hardwood							
Young male (10) ^a	125	0	0	52	0	13	190
Young female (3)	40	0	0	29	2	1	72
Adult male (2)	26	0	0	3	0	0	29
Adult female (1)	6	2	0	17	0	0	25
Σ	197	2	0	101	2	14	316
1983-1984							
From diurnal location							
Pine <3 m	0	1	0	0	0	0	1
Pine 3-9 m	8	51	0	13	2	4	78
Pine-hardwood	0	1	0	0	1	0	2
Bottomland hardwood	60	418	0	215	9	40	742
Cypress-tupelo	1	16	0	7	10	5	39
Clearcut/regrowth/shrubland	9	20	0	9	4	48	90
Σ	78	507	0	244	26	97	952
Only from bottomland hardwood							
Young male (22)	24	201	0	82	7	17	331
Young female (11)	10	83	0	38	0	10	141
Adult male (10)	19	72	0	56	1	7	155
Adult female (7)	7	62	0	39	1	6	115
Σ	60	418	0	215	9	40	742

^a Numbers in parentheses are number of woodcock.

We found no relationship between age-sex class and the probability of a woodcock moving to either a forested or a field habitat at night ($\chi^2_3 = 4.29$, $P = 0.23$).

For young males, no difference ($\chi^2 = 1.28$, $df = 1$, $P = 0.26$) was found between years in the probability of moving from a diurnal location to another location.

Distance Moved

The distance moved between diurnal and nocturnal locations did not differ by age ($F_{1,50.9} = 0.13$, $P = 0.72$), sex ($F_{1,49.3} = 1.16$, $P = 0.29$), or age-sex ($F_{1,49.6} = 0.60$, $P = 0.44$). Distance moved did differ by whether or not a bird changed habitats ($F_{1,73.3} = 55.20$, $P < 0.001$) with woodcock that changed habitats moving farther ($\bar{x} = 708$ m) than those that did not ($\bar{x} = 310$ m). Breaking down these data by whether a woodcock moved from its diurnal location to either a forested habitat or to a field habitat affected this latter outcome. Distances moved by woodcock moving to forested habitats did not differ according to age-sex class ($F_{1,30.75} = 1.59$, $P = 0.22$). An age-sex effect on the distance moved between diurnal covers and fields at night was evident ($F_{1,4.85} = 4.69$, $P = 0.08$). Further examination of this pattern revealed that there was an effect of age on distance moved to fields at night ($F_{1,4.94} = 8.97$, $P = 0.03$). Adults moved shorter distances to fields than did young woodcock.

Between years, young males showed no difference ($F_{1,726} = 0.02$, $P = 0.90$) in distances moved.

Virginia

Six fields on the refuge were used nocturnally whereas no fields off-refuge were used by radio-marked woodcock despite woodcock using forested habitats off-refuge during the day. During five evening crepuscular surveys at three off-refuge fields, no woodcock were observed. Marked birds frequenting off-refuge habitat diurnally would return to refuge fields nocturnally from up to 1.1 km away. Of the 24 marked woodcock moving off-refuge, 19 returned at least once to use nocturnal fields. Woodcock moving off-refuge did not move far ($\bar{x} = 1.9$ km, $SE = 0.870$).

No effect of age ($F_{1,64} = 0.09$, $P = 0.77$), sex ($F_{1,64} = 0.09$, $P = 0.77$), or age-sex ($F_{1,64} = 0.12$, $P = 0.74$) was found on the probability of being observed in woods (213 observations) versus fields (271 observations) on the refuge at night. The effect of age on nocturnal location is tenuous, though, as the sample size for adults was small (Table 1).

DISCUSSION

Horton and Causey (1979) found that, on any given night, 43% of marked woodcock in the Piedmont of Alabama were located in open fields. They also found significant differences by age-sex class in use of fields versus woods at night. They found that young males used fields more often than forests, young females and adult males neither preferred nor avoided fields, and adult females used forests more often than fields (Horton and Causey 1979). The use of forests by adult females was ques-

tioned, though, as half of the observations were located within 27 m of a field edge, thus half of the adult females were located 'on' a field edge. Horton and Causey (1979) noted that 27 m was the mean error in exactly locating a bird. We point out that the chi-square analysis Horton and Causey (1979) used incorporated individual observations as replicates rather than the more appropriate factor, individual birds. In not doing so, within individual variation is bound up with among individual variation and the number of replicates is misleading (B. Cade, Natl. Biol. Serv. pers. comm.). For example, not taking into account this problem, our original test results (unpubl. data) indicated the exact same age-sex patterns in moving to fields versus forests at night as was found by Horton and Causey (1979). After changing our analyses, we found no relationship between age-sex class and moving to fields versus forests at night.

Our data suggested that fields were used at night but they were not used often in Georgia. The use of fields nocturnally was year-dependent with much greater use in 1982–83 than in 1983–84. The large discrepancy in field use by year (65%, 1982–83; 13%, 1983–84) may result from our definition of field habitat. In 1982–83, 62% of all observations were in pine plantations <3 m high. Some researchers may argue that this category may not constitute 'field' habitat because the canopy was beginning to close. Excluding these observations in 1982–83 only 3%, and in 1983–84 only 5% of all birds moving ended up in clearly field habitat, clearcut, shrubland or regrowth. Excluding the pine <3 m habitat type from the field category would result in field use at night being an uncommon event, <10% of the time. Field use in Virginia was much higher, about 50% of all observations. But use of fields was specific to those fields found at the refuge. Those fields, fallow soy beans and an abandoned grass airstrip, were attractive enough to radio-marked woodcock to cause them to move up to 1.1 km during the crepuscular period. The croplands at Virginia and Georgia and the pastures in Georgia were not attractive to roosting woodcock. The lack of use of croplands at Virginia must have resulted from the management practice of removing all residual crop materials and tilling the soil flat. Similar findings have been reported by Glasgow (1958) and Connors and Doerr (1982). Residual crop materials were left on the croplands in Georgia yet still no use at night by woodcock was observed. We can only speculate that the small size of fields encountered (<5 ha) contributed to the lack of use of those fields. Size was not a factor with the lack of use of pasturelands in Georgia though as fields varied from 5–50 ha. Glasgow (1958) found that heavily grazed fields were little used by woodcock at night, but both moderately and lightly grazed pastures were available in Georgia. We cannot explain the lack of use of pastures in Georgia. Based on our findings, we hypothesize that given a choice

between field types (cropland, pastureland, clearcut), woodcock will choose clearcuts over other field types.

Although our findings suggest that the use of fields is not common, we strongly believe that the availability of fields to roost, perform courtship activities and feed in is important. In searching for woodcock to capture at the beginning of each field season, we noted that most fields had no birds, a few fields had some birds (3–10), and one or two fields had tremendous numbers of woodcock (>50). Clearly these latter fields were preferred over others, and importantly, the location of these fields must have affected where woodcock were locating themselves diurnally as woodcock moved no more than 1.1 km to a nocturnal field. We hypothesize that these fields were attractive because of their size, location relative to preferred diurnal habitat, amount and height of ground cover.

The shift in use of managed pine sites at night between years at Georgia reflects the availability of the two habitat types between years. Between 1982–83 and 1983–84, most of the pine <3 m grew into the next type, pine 3–9 m. Thus, the increased use of pine 3–9 m in 1983–84 indicated that woodcock were using what was available rather than a shift in preferences between years. Use of managed pine sites during the day was found to be in accordance to the amount of habitat available (Krementz and Pendleton 1995).

If our data are representative of the norm, then the use of relative abundance data collected on fields at night during the winter would clearly underestimate the true number of birds in the general area being surveyed (Tappe et al. 1989). This would not be a problem in deriving inferences about population trends on wintering grounds unless the proportion of woodcock frequenting fields at night is year-dependent. Our data from young males did not suggest a year effect on probability of movement. If there are year effects on field use at night, then numbers of woodcock counted using fields would be confounded with time and no valid inferences regarding population trends could be legitimately drawn.

Horton and Causey (1979) monitored distances moved during the crepuscular period and found most birds moved >100 m (65% of observations) with a mean of 183 ± 28 m. Our findings for those birds moving from one habitat type to another habitat type differed greatly with crepuscular flights being, on average about 700 m. In Georgia, the bottomland hardwoods frequented diurnally were quite extensive, >1 km wide. Woodcock would typically move quite far into these bottomland stands during the morning crepuscular flight. Examination of the study area map of Horton and Causey (1979) suggests that deep bottomland hardwoods were not available. Without the option of extensive bottomland hard-

woods, woodcock apparently had no choice but to remain close to openings and so fly shorter distances during the crepuscular period.

Most data on age ratios of woodcock captured in nocturnal fields indicate that adults are captured less often than young (Dwyer et al. 1988, Roberts 1993, Sepik and Derleth 1993). Several hypotheses have been offered to explain this phenomenon including: (1) adults frequent nocturnal fields less often than do young (Gregg 1984, Owen and Morgan 1975, Sepik and Derleth 1993), (2) fewer adults are available to capture than young (Sepik and Derleth 1993), and (3) adults are less easily captured than young (Connors and Doerr 1982).

Our data do not support the first hypothesis as adults were as likely to frequent fields nocturnally. Rather, our data suggest that adults are less abundant, or they are less easily captured. Based on band recovery data, Martin et al. (1965) found that young woodcock were more likely to be shot nearer the Atlantic coast than inland compared to the probability of shooting an adult. They hypothesized that this pattern was a consequence of young woodcock being diverted eastward because of prevailing westerly winds. Thus, our coastal study sites should have a preponderance of young woodcock. Connors and Doerr (1982) observed that adult woodcock were nonrandomly distributed in nocturnal fields with adults tending to frequent the edges of fields rather than the interior sections. This observation was also made by Horton and Causey (1979). The close proximity to the field edge may enable adult woodcock to walk or fly to escape cover quickly, and so avoid capture.

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